# MULTIMEDIA UNIVERSITY

# FINAL EXAMINATION

### TRIMESTER 2, 2016/2017

### EBT3036 – MEDICAL IMAGING
(BE)

24 FEBRUARY 2017
9.00 a.m – 11.00 a.m
(2 Hours)

## INSTRUCTION TO STUDENT

1. This Question Paper consists of 5 pages with 4 Questions only.

2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

   a) Please write all your answers in the Answer Booklet provided.

## QUESTION 1

a) Define what radionuclide is and give one example of radionuclide from Carbon family.                                                                    [2+1 marks]

b) State the four types of radioactive decays. What types of decays are used for SPECT and PET imaging, respectively?                                   [4+2 marks]

c) Suppose we have $2 \times 10^{12}$ Technetium-99m (Tc-99m) atoms to start with. Given the half-life for Tc-99m is 6 hours.

   i) What is the radioactivity of Technetium-99m at t=0?                    [2 marks]
   ii) Determine how long will it take for the original activity of the Technetium-99m atoms to decay to activity 1 mCi.                              [6 marks]

d) One of the desired properties of a radiotracer is that it needs to be a safe and useful tracer for a human body. Explain the other four desired properties of a radiotracer.
                                                                            [8 marks]

**Continued...**

## QUESTION 2

a) Give the frequency range for medical ultrasound imaging.                    [2 marks]

b) Consider an acoustic wave encounters a muscle/bone interface at normal incidence. The acoustic impedance of muscle is $1.7 \times 10^5$ $gcm^{-2}s^{-1}$ and the acoustic impedance of muscle is $7.8 \times 10^5$ $gcm^{-2}s^{-1}$.

   i) Determine the fraction of the acoustic intensity that is reflected back from the muscle/bone interface.                                      [4 marks]
   ii) What is the transmitted intensity in this case?                    [2 marks]

c) A 5 MHz ultrasound transducer is pointing down to the +z axis. At time t=0, it generates an acoustic pulse in the form of:
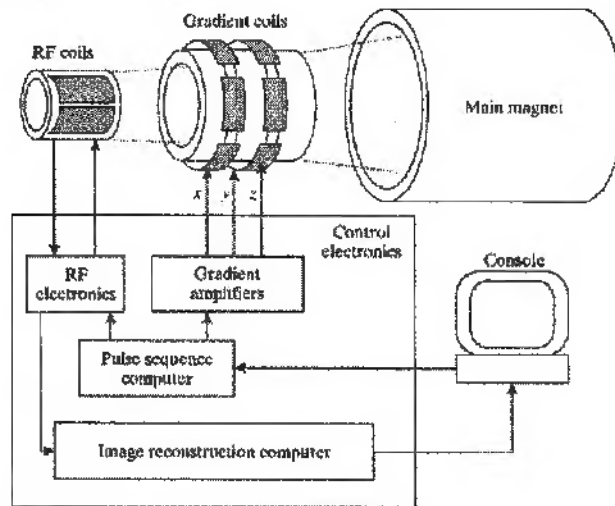
$$\phi(t) = \left(1 - e^{-t/\tau_1}\right)e^{-t/\tau_2}$$

   i) Write down the equation of the forward travelling wave down the +z axis.

                                                                        [2 marks]
   ii) Assuming the acoustic pulse travels from the face of the transducer through 1 cm layer of fat before going into a liver. At what time does the leading edge of the impulse hit the first interface? The speed of sound in fat is 1450 $ms^{-1}$.   [3 marks]
   iii) Explain the attenuation processes that act on the acoustic pulse from the moment it leaves the face of the transducer until an echo is received.          [12 marks]

**Continued...**

## QUESTION 3

a) Discuss the main principles in Nuclear Magnetic Resonance (NMR).  [6 marks]

b) Explain the functions for each of the five main components of an MRI scanner as given by **Figure Q3.1** below.  [10 marks]
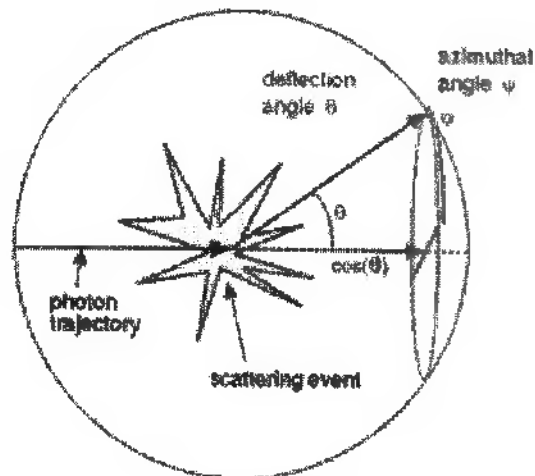


**Figure Q3.1**

c) The basic NMR signal is a sinusoid at the Larmor frequency. Explain the factors that affect the magnitude of an NMR signal.  [9 marks]

**Continued...**

## QUESTION 4

a)  Briefly explains four importance of photon absorption in biomedical optics. [8 marks]

b)  **Figure Q4.1** below shows a photon trajectory before and after a scattering event. Discuss the relationship between anisotropy, scattering coefficient and reduced scattering coefficient.                                                                 [10 marks]



**Figure Q4.1**

c)  Given the transmitted ratio of an optical photon after penetrated 150 μm of soft tissue is 1%. Determine the total attenuation coefficient of the soft tissue and the corresponding mean free path of the optical photon propagating in the soft tissue. Ignore the effect of specular reflection.                                          [7 marks]

**End of Paper**